Application/Control Number: 10/739,207

Art Unit: 285

Previously presented

Title of the Invention –

Method for

supplying variable voltage

to an electric circuit.

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Amended patent application with affidavit, which

Places the application in condition for allowance.

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Previously presented

CROSS REFERENCES TO RELATED APPLICATIONS

001 Adolph Mondry – System and method for automatically maintaining a

blood oxygenation level. P.N. 5,682,877, November 4, 1997 – herein

referred to as 877. The flow sheets of that device are similar to those of this

method.

002 Meland Kantak – Internal fuel staging for improved fuel cell

performance. P.N. application 20020081479 – herein referred to as 479. A

similar device is used in this method.

003 Thomas L Cable – High performance fuel cell interconnect with

integrated flow paths and method for making same. P.N. application

200300877498 – herein referred to as 498. A similar device is used in this

method

Konishi et al –US Publication 20060087248, Andricacos et al –US

Publication 20040077, and Mahoney et al-6504294 – do not take the

circulation time from voltage production to voltage sensing as the device presently considered does.

FEDERALLY SPONSORED RESEARCH GRANTS

004 There are no Federally sponsored research grants available to those involved in the research and development of this method.

Previously presented

BACKGROUND OF THIS INVENTION

005 (Previously presented) Fuel cells and many devices that are voltage producing sources, such as solar cells, must constantly generate the full amount of voltage needed to operate all connected circuits. ~~Connections between these devices will be needed as requirements expand.~~ It is desirable to have a method available, which automatically controls circuit voltage to minimize the need for constant maximum voltage generation in fuel cells and other voltage producing devices without compromising circuit function; ~~and which provides automatic switching~~.

Previously presented

BRIEF SUMMARY OF THE INVENTION

006 (Amended for clarity) It is an object of the present invention to provide a method to control voltage in fuel cells and other voltage producing sources to produce and deliver appropriate varying circuit voltage to decrease continuous maximum voltage production by placing the negative electrode of the voltage producing source in a predetermined range. ~~It is a further object of this method to provide automatic switching between these devices to provide extra voltage when needed.~~

007 (Amended for clarity) In carrying out the above objects and other stated objects and features of the present invention a method is provided for maintaining a desired voltage at the negative electrode (herein named the entrance voltage) of a voltage producing source, and includes delivering a first maximum voltage producing dose, where dosage is defined to be the tracing of a logarithmic function or its reflection or a straight horizontal line plotted in the Cartesian plane, where negative electrode voltage is placed on the ordinate and time, reactive gas flow rate or the voltage producing level, and positive electrode voltage are placed on the abscissa and here determines a positive electrode voltage at the positive electrode of the voltage producing source as an exit voltage dose and level selected from

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one of a plurality of exit voltage doses and levels between a smallest exit

voltage dose and level and a largest exit voltage dose and level. The method

includes delivering a maximum voltage producing level to the circuit

connected to the device while repeatedly sequencing through the plurality of

sequential exit voltage doses and levels beginning with the smallest exit

voltage dose and level and proceeding continuously to the next ~~an adjacent~~

exit voltage dose and level in ~~the~~ a sequence after a predetermined time

interval has elapsed. The largest voltage producing level and consequential

exit voltage dose are delivered until the entrance voltage attains the a

desirable level, at which point a corresponding exit voltage dosage and level

are selected from the plurality of sequential exit voltage dosages and levels.

The method also includes delivering the selected exit voltage so as to

maintain the desired entrance voltage. The method is based on the fact that

in the Cartesian plane at the intersection of the maximum or minimum

voltage tracing with the desired entrance voltage the abscissal value of that

intersection is the exit voltage, which maintains the entrance voltage in its

desired range.

008 (Amended for clarity) In the preferred embodiment the method

automatically selects an appropriate reactive gas flow rate to maintain a

desired entrance voltage level of a fuel cell, for which the system is

particularly suited, and is the preferred voltage producing source, and

includes delivering a first maximum reactive gas flow rate as a voltage producing level to the fuel cell, producing an exit voltage level and dose in the fuel cell selected from one of a plurality of exit voltage levels and doses between a ~~smallest~~ minimum exit voltage dose and level and a maximum exit voltage dose and level. The method includes delivering the maximum reactive gas flow rate to the fuel cell while repeatedly sequencing through the plurality of sequential exit voltages beginning with the smallest exit voltage and proceeding to the next larger ~~an adjacent~~ exit voltage in the sequence after a predetermined time interval has elapsed. The maximum reactive gas flow rate is delivered until the entrance voltage attains the desirable level, at which point a corresponding exit voltage and reactive gas flow rate are selected from the plurality of sequential exit voltages and reactive gas flow rates. The method also includes delivering the selected exit voltage and the reactive gas flow rate so as to maintain the desired entrance voltage level.

009 (Amended for clarity) The advantages of the method are minimal needs for constant maximum voltage production in fuel cells and other voltage producing sources, ~~the availability of switching voltages between these devices as the need arises~~, and a potential reduction in the cost of electricity.

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010 (Previously submitted) The above objects, features, and other advantages will be readily appreciated by one of ordinary skill in the art from the following detailed description of the best mode for carrying out the method, when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

011 (Original) Fig. **1/6** demonstrates a perspective view of the first embodiment of the present method.

012 (Original) Fig. **2/6** is a graphical demonstration of the flow charts of the present method

013 (Original) Fig. **3/6-5/6** are flow charts dealing with the voltage and reactive gas strategy of the present method.

014 (Original) Fig. **6/6** is a flow chart for relating parameters in the present method.

DETAILED DESCRIPTION OF THE INVENTION

015 (Amended for clarity) Referring now to Fig. **1/6**, a first embodiment of the present method is shown. This embodiment indicated by reference number **1** in Fig. **1/6** is the best mode in implementing this method and is particularly suited for use in the present method. Figure **1/6** includes two voltimeters **2** and **3** - one voltimeter **2**, which measures exit voltage – v1 at the positive electrode **4** of a voltage delivery system and a second voltimeter **3**, which measures entrance voltage – v2 – at the negative electrode **5** of a voltage delivery system. Two band pass electrical filters **7** and **8** are connected to each voltimeter **2** and **3**, then to an electronic control unit (ECU) **9**, which exercises control strategy, and processing and analyzing voltage data to maintain v2 in a specific range. The ECU **9** preferably operates on power delivered from either D.C. or A.C.power supplies allowing portability to the method.

016 (Previously submitted) With continuing reference to Fig. **1/6** a fuel cell **10** as described in U.S. patent application 498 is added as the preferred embodiment of a voltage delivery system. The two reactive gas flow rates at the inlets **11** are controlled by two ECU **9** controlled variably opening solenoid valves **12** with Coulomb controlling circuits, as was taught in 877 and United

States P. N. 5,008,773. Reactive gases pass through an electrolyte solution **13**, then react at the electrodes **14**. A typical reaction is $2H2+O2=2H2O+4e-+heat$, thus producing voltage in an electric wire **15** with resistance **16**. A circuit **6**, such as that of a family dwelling, is pictured. Adequate voltage delivery here is the object of the present embodiment. A battery **17** is supplied for use when extra power is needed. Optional DC/AC converters **17** and AC//DC converters **6** are included for better use of conventional appliances.

017 (Amended for clarity). Referring now to Fig. **2/6**, the method of device function is demonstrated graphically. As was previously stated, negative electrode voltage is placed on the ordinate and time, reactive gas flow rate, voltage producing level and positive electrode voltage are placed on the abscissa of a Cartesian plane. Maximum or minimum reactive gas flow rate or voltage producing level occurs at tR on the abscissa, the significance of which will be presented later. Measured and calculated logarithmic functions or their reflections or straight horizontal lines are used in the preferred embodiment as exit voltage levels or positive electrode voltage (v1) dosages, but any measured and estimated transcendental function with an inverse may be used.

018 (Original) Referring again to Fig. **1/6**, as will be seen, conditions on v2 – the entrance voltage - control reactive gas flow rate **11** and thus v1 - exit

voltage, circuit voltage, circuit voltage dosage, and finally entrance voltage –
v2 – itself.

019 (Amended for clarity) Referring now to Fig. **2/6**, the illustrated
method of reactive gas flow rate and exit voltage selection starts with the
administration of a maximum reactive gas flow rate producing a
consequential maximum voltage producing dosage – herein referred to as the
selector dose of the reactive gas flow rate which produces a local maximum
exit voltage dose at the positive electrode of the fuel cell or of any voltage
producing device – as in curve A. Curve A is represented by the tracing of
the function y=log to the base a of x in Figure **2/6,** where a is the smallest
base in the system.. Curve A activates at x=0. It is named Max R. Curve B
represents MINR. It is herein traced as y=1/x. It is the reflection of MAXR
across the line CG, described later. Curve B activates at x=0.Which curve is
used depends on the proximity of any value to each curve. At their
intersection prior derivatives with respect to time determine which curve is
used.

020 (Amended for clarity) Line CG is the desired voltage of v2 – herein
referred to as the selection parameter, which is a range in the actual method.
At the intersection of line CG and curve A or B (call it X), line D points to
point E on the abscissa as the selected reactive gas flow rate or the voltage
producing level and the exit voltage. This is determined by graphical means

and, as will be seen, the flow charts. The virtual exit voltage dose is curve F, which activates at point E, the selected voltage producing level and the positive electrode voltage, and is boosted by curves A, B, H – an overshoot of curve A – and curve I – a deactivation of curve H – to produce line G, which is the selected entrance voltage, because it is a horizontal line, and is represented by y=log to the base b of tr, where tr is the t value of the flattening out of the logarithm y=log to the base b of t (curve F) at tr seconds by line G. Line G is completely determined by the intersection (X) described above and in the flow charts, as will be seen. Curve F and line G start in the x coordinate system at x=tR and in the t coordinate system at t=0, when curve A or B deactivate. Curve F and G deactivate when curve A or B activates. Curve J is the virtual curve of curves A and H. K marks the Circulation time. It marks the time from the initial reactive gas flow rate to the first recording of v1. Its accuracy is essential for proper flow chart function with respect to time. Its calculation and that of tr will be demonstrated. The voltage producing level and the exit voltage are circulation time dependent. At line CG v1 usually differs from v2 in value. At the above mentioned intersection (X) v2 is in its desired range and v1 is selected as the selected exit voltage and voltage producing level..

021 (Original) Before describing the flow charts it is useful to explain the terminology employed. The most recent base state keeps v2 (the entrance

voltage) in its desirable range. V1 (the exit voltage) and v2 are measured in all states and their tracings are calculated in all states. The washout state washes out overshoots. For the fuel cell exit voltages are functions of reactive gas flow rates. For other voltage producing devices, exit voltages are functions of other voltage producing mechanisms - motion, magnetism, heat or technologies producing heat.

022 (Original) Referring now to Fig. **3/6-5/6**, flow charts are shown, which illustrate the method of proper selection of exit and entrance voltages, voltage producing levels or reactive gas flow rates.

023 (Original) Referring to Fig. **3/6,** Step **400** determines various system parameters, which may be predetermined and stored in memory, calculated by an ECU (such as ECU **9** in Fig. **1/6**) or entered by a system operator. The system parameters include the following:

MIN R=minimum dose of exit voltage given for each range.

MAX R=maximum dose of exit voltage given for each range.

V1=exit voltage.

Range=flow charts with different durations of increments.

IR=available dose increments for each range.

V2=entrance voltage. When it equals zero for ten seconds, the device deactivates and reactivates when the battery discharges in response to the closing of a circuit switch.

dL=low v2 threshold.

dH=high v2 threshold.

TSS=series state delay time.

Tcirc=circulation delay time.

Twash=washout delay time.

tR=desired response time or reaction time. It occurs at dose selection.

To calculate dH and dL close all circuits. Increase v1 until all circuits first function properly. Measure v2. Do the same with the smallest circuit. Compare v2. The larger voltage is dH. The smaller voltage is dL. For ties add or subtract circuit devices.

024 (Original)As shown in Figure **3/6** the ECU now passes control to Step **402**, which measures v1 and v2. At Step **404** a maximum exit voltage dose of the last range is administered. This is represented graphically by curve A of Figure **2/6** and is called the selector dose. It represents the maximum exit voltage dose. The possible exit voltage dose is set for the lowest dose of the lowest range, which is the first dose in a sequence of possible exit voltage dosages from the lowest to the highest dose.

025 (Original)With continuing reference to Figure **3/6** at Step **406** v1 is maintained while pausing Tcirc seconds, then x is set to 0 seconds. Step **406** is called an adjustment state. It coordinates the flow charts with respect to time. Initial circulation times may be estimated or measured.

026 (Original) Referring once again to Figure **3/6** the ECU passes control to Step **408**, which continues to deliver maximum exit voltage doses to v1. Step **408** is referred to as a series state -Tss – and is necessary to coordinate the progression through various possible exit doses within a time period determined by tr. The calculation of Tss depends on the current operating state. Some representative calculations are illustrated in Figure **6/6** for a single ranged implementation as discussed in greater detail below.

027 (Original) Still referring to Figure **3/6** a test is performed at Steps **409** and **410.** It asks – is v2 greater than dH? – and, is v2 less than dL?, respectively. They split control into three pathways. Negative answers to both conditions direct control to Step **426**, where 1. The exit voltage dose is set to the possible exit voltage dose and directs the voltage producing level to its abscissal value in the Cartesian plane.2. A pause for the circulation time does not take place, because there is none here, because all space below line G of Figure **2/6** is flooded by the space above it. Then, 3. t is set to 0. This represents the voltage producing level or reactive gas flow rate and exit voltage selection. This occurs at x=tR, the reaction time.

028 (Original) Now referring to Figure **4/6** processing continues with the ECU directing control to Step **428**, which pauses to washout high valued functions from the selected dose. The state is completed when all involved functions equal a straight horizontal line – the selected entrance voltage

level – then this dose is activated. The entrance voltage level remains the selected voltage as line G in Figure **2/6**. This dosage continues until activation of MIN R or MAX R. Step **430** measures voltage values for the Conditions below. Steps **432** and **433** represent a second test and ask the same questions as the above mentioned first test – Is v2 greater than dH or less than dL, respectively? If either answer yes, control is directed to Steps **431** and **434,** respectively, where a predetermined fraction of tr is either subtracted or added, respectively to tr. This pathway determines tr only if the circulation time is correct. The circulation time is calculated by keeping the last three base state values in memory. When control is directed to or beyond a noncontiguous base state from which control was originally assumed a predetermined amount of time is added to the circulation time. This will correct abnormally short circulation times. For abnormally long circulation times – if control passes consecutively to two ascending or descending base states, a predetermined amount of time is subtracted from the circulation time.

029 (Original) Referring now to Figure **5/6,** if both conditions in the second test answer no, the ECU places control in Step **436**, the base state. Steps **438** and **440** represent the third test and ask the same questions (is v2 > dH or < dL?) as those of the previous tests with different consequences. They determine the stability of the base state (both conditions answer no if it

is stable). If it is unstable, the ECU directs control to either Step **463,** if Step **438** answers yes, or **446,** which 1. Minimizes or maximizes the exit voltage dose, respectively 2. Pauses for the circulation time, then 3. sets x=0. These doses continue until dose selection. It should be noted that Steps **431, 434,** the yes part of **418,** and the no part of Steps **433** and **440** all yield control to Step **436,** the base state. The ECU then directs control from Step **463** to Step **411,** and from Step **446** to Step **412.**

030 (Original)Referring again to Figure **3/6,** the ECU directs control from Step **464** (evaluated later), and if Step **414** in Figure **4/6** (the first condition of the fourth test to be elucidated soon) answers no, to Step **408** to maintain the exit voltage for Tss. Control is then directed to Step **409,** which, if along with Step **410** - the first test – the answer is yes to both conditions, control is passed to Steps **411** and **412,** respectively, which decrement and increment the possible exit voltage, respectively, then both pass control to Condition **414.**

031 (Original) Referring now to Figure **4/6,** Steps **414** and **418** represent the fourth and final test with different conditions than the other tests. This test asks if the present possible exit voltage is the last one available, and if the present range is the last one available, respectively. If Step **414** answers no, control is directed by the ECU to Step **408** in Figure **3/6,** which maintains the exit voltage for Tss. If the condition answers yes, control is

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directed to Step **418**, which determines if the present range is the last range available. If it answers no, control is directed to Step **464,** in which control enters a new range, sets the exit voltage and dosage to MAX R or MIN R of the new range, pauses for the circulation time, then sets x=0. Control is then directed to Step **408**, which maintains an exit voltage for Tss. If Step **418** answers yes, the ECU directs control to Step **436**, the base state.

032 (Original) Referring now to Figure **6/6** a flow chart is shown illustrating representative calculations of Tss according to the present invention. One of these calculations or an analogous calculation is performed for each series state of Figure **3/6-5/6**, such as illustrated at Steps **408, 411,** and **412**.

033 (Original) Returning to Figure **6/6** at Step **480** a test is performed to determine if the system has reached a base state. If not, the series state delay is estimated as: Tss=tr/IR. If the result is true, the process continues with Step **484**, where a test is performed to determine whether v2<dL. If true, then Step **486** determines whether the most recent base state is a minimum for the current range. If it is true, the series state delay is calculated by Step **488** as Tss=tr/(IR-1). Step **498** then returns control to the series state which initiated the calculation.

034 (Original)) With continuing reference to Figure **6/6,** if the test at Step **486** is false, then the series state delay is calculated by Step **490** as

Tss=tr(MAX R-MIN R)/(IR-1)(MAX R-BASE STATE) before control is released to the series state via Step **498.** If the test performed at Step **484** is false, then Step **492** performs a test to determine if the most recent base state is the maximum for the current range. If the result of Step **492** is true, then Step **496** calculates the series state delay as Tss=tr/(IR-1). Control is then returned to the appropriate series state via Step **498.** If the result of the test at Step **492** is false, then the series state delay is calculated by Step **494** as Tss=tr(MAX R-MIN R)/(IR-1)(BASE STATE-MIN R). Step **498** then returns control to the appropriate series state. Figure **6/6** applies to a single range. One of ordinary skill in the art should appreciate that the calculations may be modified to accommodate a number of possible ranges.

035 (Original) It should be apparent to any one skilled in the art that the flow charts provide the demonstrated method.

036 (Original) Different devices use different means to produce voltage. Fission reactors, mechanical/magnetic reactors, fusion reactors, solar cells, steam/turbine reactors, and fossil fuel burning reactors can control voltage in corresponding circuits by the same method. The range used for v2 depends on the application – the largest voltage drop across the circuit and the smallest voltage drop across the circuit. ~~Switching function between voltage producing devices employs Step 418 of Figure 4/6 – last range available? – If it answers yes, control passes to Step 436, the base state, where voltage~~

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passes from the device. For all other steps, voltage is transferred to the device.